

only in the foehn and dry chinook winds but on the south side of our low areas and, notably, over large portions of the Mississippi Valley and the eastern slope of the Rocky Mountains, which are subject to occasional extremely high temperatures, relatively speaking, without any special increase in the heat from the sun or the clearness of the sky.

But to return to the lecture by Professor Linde, the *Vossische Zeitung* says:

The January meeting, held on the 6th of January under the presidency of Privy Counselor Professor Rietschel, was one of the greatest events in the history of the Berlin Society of Engineers. Prof. Dr. Karl Linde of Munich exhibited his magnificent experiments on the condensation of gases and showed liquid air in such quantities that it was handed around to the audience by the glassful. In order that these experiments might be made, the session was not held in the usual place of meeting, but in the electro-technical lecture room of the Technical High School at Charlottenburg near Berlin, and among the audience which filled up every corner of the large hall were to be seen nearly every person of note among the professional engineers, the teachers of engineering and the higher technical authorities. The lecture began with a dissertation on the physical conditions attending the condensation of gases. At certain pressures every gas has certain "critical" temperatures at which it begins to become fluid. For atmospheric air under a pressure of 39 atmospheres the critical temperature is -140°C ; at ordinary, or one atmosphere, -191°C . Now the question is how this low temperature is to be produced. One way is, first, to prepare fluid carbonic acid, then with the help of the cold of evaporation of this substance (-50°C) to prepare acetylene or some other liquid gas whose boiling point is considerably lower than that of the liquid carbonic acid. This method has, however, been abandoned as too laborious and expensive. Much simpler is the method by the compression of the gas and its expansion after cooling; that is to say, on the principle of the ordinary cold air machine, only of a more perfect construction. When a gas is compressed it becomes warm; when released so that it occupies the original space, there occurs a cooling back to the original temperature. If, however, the heated gas be cooled off while it is still compressed and then allowed to expand there will result a cooling to some point below the original temperature and this temperature will, in fact, be lower in proportion to the cooling of the compressed gas. A very ingenious apparatus has now been contrived in which the cooling of the condensed gas is effected by means of its own cooling by expansion. A small metal tube is placed within a larger one; the compressed gas is forced into the small tube. A throttle valve on the end of the small tube allows a diminution of pressure and at the same time the conduction of a part of the expanded and cooled gas backward through the larger tube. The direction of the flow of the gas in the large tube is therefore opposite to that in the small tube so that the cooling takes place in the most perfect manner. By the repetition of this process the second diminution of pressure brings the gas down to the ordinary atmospheric pressure and by a second application of the cooling flow in the opposite direction we attain extraordinary low temperatures and in this way succeed in liquefying the air itself.

A double compressor first compresses the air to 16 and then to 200 atmospheres; vice versa in the cooling tubes the first throttle valve allows a diminution of the pressures to 16 atmospheres and the second to one atmosphere. The liquid air thus obtained, since of course it will not remain liquid under ordinary conditions, but will very rapidly evaporate, is collected and preserved in glass flasks having double walls.

The space between the two walls of the glass flask is exhausted of the air and a few drops of quicksilver are inserted therein. This quicksilver evaporates into the vacuous space and forms a mirror by condensing on the cold inner glass wall. This mirror hinders the radiation of heat while the vacuum hinders the conduction of heat. In this way scarcely a thirtieth part of the heat enters the liquid that would under ordinary circumstances penetrate into the interior of the flask.

It is well known that the air is a mixture of four parts of nitrogen and one part of oxygen and since the nitrogen is liquefied at a temperature about 10°C lower than that of oxygen, it is apparent that at the beginning of the liquefaction more oxygen than nitrogen passes over into the liquid condition. We are, therefore, dealing not strictly with fluid air, but with a mixture of oxygen and nitrogen that is richer in oxygen than ordinary air. The liquid exhibited to the audience consisted of about one-third nitrogen and two-thirds oxygen. It demonstrated its richness in oxygen visibly by its delicate blue color since oxygen is blue and nitrogen colorless, as, also, by the readiness with which a glowing bit of wood dipped into it flamed and burned, as also, by the increased heat produced in a flame of gas when this vapor was conducted into it; the lecturer showed this heat effect by means of the well-known Drummond lime light. The extreme coldness of the liquid was demonstrated by the formation of fog in the neighboring air, as also by the behavior of the fluid when poured into

an enameled dish having the temperature of the room; in this case the fluid circled around until the dish was cooled precisely as in the Leidenfrost experiment when water is dropped into a heated platinum dish. Such extraordinary cold produces burns on human skin similar to those produced by great heat. Therefore, one must handle the cold glass vessels with great care; in the enthusiasm of the experiment the lecturer himself received such a blister, which, therefore, served as a further illustration of the low temperature of the liquid. Mercury and alcohol froze when in contact with the liquid air.

What the lecturer said as to the possibility of the industrial applications of liquid air or liquid oxygen was of importance. Of course the separation of the two portions of the air into one that liquefies easily and one that liquefies with more difficulty suggests the question whether we have not here found a method of cheaply manufacturing oxygen on a large scale. In one hour and with the expenditure of one horse-power, and therefore for one pfennig (one-quarter of a cent) five cubic meters of air can be liquefied. When we reflect that for industrial applications pure oxygen is not necessary, but that a mixture of equal parts of oxygen and nitrogen will suffice, we see at once that here there really is much promise for the future. Industrial chemistry is already paying great attention to this matter; experiments have already been made looking to the application of liquid air to the preparation of chlorine and sulphuric acid. A greater purity of the liquid oxygen is certainly desirable in the transportation of the liquid in "bomben," or shells, corresponding to the transportation of liquid carbonic acid.

THE VALUE OF THE METER AND YARD.

The REVIEW for December, 1896, page 462, gives the value of the yard that is recommended for adoption by the International Bureau; 0.9143992 meter, or 1 meter equals 1.0936143 yard, or 39.370113 inches. It is not recommended that one should adopt 0.91439916 meter, whence would follow, 39.370115 inches. The latter value has been commended to the Editor as the proper result of the work of the International Bureau, but it is best to adhere to the value recommended by that body.

INTERNATIONAL CLOUD OBSERVATIONS AT TORONTO.

In connection with the articles on international cloud observations in the United States, the Editor has received (too late for insertion on a former page), through Prof. R. F. Stupart, Director of the Canadian Meteorological Service, the following special contribution describing the method of observation in use at the Toronto Observatory.

CLOUD OBSERVATIONS AT TORONTO.

By F. L. BLAKE, Astronomical Assistant, Meteorological Observatory (March 5, 1897).

Observations for cloud heights, velocities, and directions were commenced at Toronto on September 21, 1896. Some time had been previously taken up in locating suitable stations and determining the bearing of the base line, its length, the instrumental errors of the instruments, and making telephonic communication. The roof of the School of Practical Science, a little to the east of the Observatory grounds, was chosen as one station and called A (all the cloud heights being referred to it), and for the other the roof of St. Andrew's Market, this station being called B. These stations are visible from one another and numerous observations of the sun were taken from each to establish the bearing, the resulting adopted direction being $S. 15^{\circ} 23.6' W.$ from A. The length of the base line was accurately determined by rectangular chaining with a 100-foot steel ribbon chain and ascertained to be 1552.4 meters.

The instruments consist essentially of two ordinary surveyors' theodolites, the telescopes being removed and a long axis made for each and mounted in the Y's of the standards. These axes project some 4 or 5 inches clear of each side of the theodolite, and on one arm is mounted a sighting tube with cross wires at the object end and small adjustable pin hole at the eye end; on the other arm is fixed a camera for the instantaneous taking of cloud photographs; attached to each

axis is a vertical circle for elevations reading to half minutes. The zeros of the azimuth plates are made to correspond with the direction of the base line and read from the south through the west completely around the circle. The method of taking the observations is as follows: The chief observer selects some well defined point of a cloud and telephones its position and other information as to its situation and form to the observer at the other station, and on his identifying it the two observers, upon a telephone signal, sight it at the same instant of time. The time is recorded; the two altitudes and azimuths are then read, and the cloud is allowed to drift on as long as the selected point retains its form when a second pointing is taken and altitudes and azimuths are read and time interval ascertained. This interval varies at different observations from about 40 seconds to 8 or 10 minutes. Here comes in the great uncertainty of this kind of observation, the lower cumulus clouds of about 1,000 meters elevation present, as a rule, well-defined points, but these change so rapidly, and their aspect as viewed from the two stations are so different, that at times it is almost impossible to get a good observation. In fact the observer, after reading his angles in many cases, can not identify the point he has selected (although well defined at the time) after an interval of only thirty seconds, and notwithstanding the fact that he looks occasionally at the cloud during the operation of reading the instrument.

Stratus clouds, as a rule, are difficult to observe. Rifts appearing here and there afford chances, but these change so much that not more than a minute or a minute and a half can be depended upon for a time interval.

The higher cirrus clouds, especially when there are any signs of nuclei, present a fair field for observations, but being so far distant they require pretty accurate pointing.

The uncertainties of the pointings on the clouds mask any small changes taking place in the instrument, such as changes in the level, and these are taken no notice of after the instruments are once adjusted and occasionally verified.

Station B is some 20 meters lower than A, but the station is assumed to be in the same plane as A, to simplify the calculations. Four observations are thus made, two at each station, from which four heights the velocity and direction of the clouds are obtained. Generally the heights, etc., of the higher clouds are calculated, but the lower clouds and alto-cumuli of about 4,000 meters are plotted on a specially made table, the base line being laid down on a scale of about

300 meters to the inch, using two protractors of three feet radius with vernier reading to minutes, having their centers at each of the stations. The vernier is attached to a movable arm, which can be applied to either station. The angles as read by the instruments are plotted on the table, and the heights, distances, and directions scaled off.

Not much photography has been done as yet, it having been found that in practice great difficulty is encountered in keeping the cameras in adjustment. These cameras were mounted primarily to act as an auxiliary in confirming the accuracy of the pointings of the telescopic tubes and to help in the classification of clouds and show any peculiarity in their formation. By constant practice the observers have become familiar with the descriptions of the clouds and the points to be taken, so that now comparatively few failures result from a misunderstanding of directions, thus rendering photographic work less necessary.

During December, January, and February the weather here has been very cloudy, affording few opportunities for observation.

Roughly speaking, the higher cirrus during September and October was found to move from the direction of about N. 40° W., while through November, December, January, and February they shifted to N. 65° W., at elevations ranging between 8,140 to 10,300 meters and traveled at velocities varying from 60 to 113 miles per hour. The highest cirrus measured was on September 24, at an altitude of 10,300 meters, with a velocity of 79 miles per hour, moving from N. 39° 13' W., while the lowest was at 8,140 meters, moving at 55 miles per hour from N. 64° W., on October 29.

Medium-height clouds, such as alto-cumulus, cirro-stratus, etc., seem to occupy heights of from 4,000 to 7,000 meters, traveling in directions varying between S. 50° W. and N. 50° W., at velocities of from 30 to 70 miles per hour.

Lower cumulus clouds generally come from the southwest and northwest at altitudes of 1,200 to 2,500 meters and velocities of 10 to 45 miles per hour.

Of the lower cloud drift, such as scud, some observations have been obtained at elevations of 600 to 1,000 meters, with velocities of about 25 miles per hour.

A sufficient number of observations has not as yet been obtained to afford data on which to base satisfactory conclusions, but it is hoped that during the year great progress will be made both in the instrumental and photographic method.

METEOROLOGICAL TABLES.

By A. J. HENRY, Chief of Division of Records and Meteorological Data.

Table I gives, for about 130 Weather Bureau stations making two observations daily and for about 20 others making only the 8 p. m. observation, the data ordinarily needed for climatological studies, viz, the monthly mean pressure, the monthly means and extremes of temperature, the average conditions as to moisture, cloudiness, movement of the wind, and the departures from normals in the case of pressure, temperature, and precipitation; the altitudes above ground, the total depth of snowfall, and the mean wet-bulb temperatures are now given.

Table II gives, for about 2,400 stations occupied by voluntary observers, the extreme maximum and minimum temperatures, the mean temperature deduced from the average of all the daily maxima and minima, or other readings, as indicated by the numeral following the name of the station; the total monthly precipitation, and the total depth in inches of any snow that may have fallen. When the spaces in the snow column are left blank it indicates that no snow has

fallen, but when it is possible that there may have been snow of which no record has been made, that fact is indicated by leaders, thus (....).

Table III gives, for about 30 Canadian stations, the mean pressure, mean temperature, total precipitation, prevailing wind, and the respective departures from normal values. Reports from Newfoundland and Bermuda are included in this table for convenience of tabulation.

Table IV gives detailed observations at Honolulu, Republic of Hawaii, by Curtis J. Lyons, meteorologist to the Government Survey.

Table V gives, for 26 stations, the mean hourly temperatures deduced from thermographs of the pattern described and figured in the Report of the Chief of the Weather Bureau, 1891-'92, p. 29.

Table VI gives, for 26 stations, the mean hourly pressures as automatically registered by Richard barographs, except for Washington, D. C., where Foreman's barograph is in use.